PCT/GB 2004 / 0 0 4 9 8 1

INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.

Signed

Dated 7 January 2005

BEST AVAILABLE COPY

Patents Form 1/77

Patents Act 1977
(Rule 16)

The Patent Office

25NOV03 E954708-2 010002
P01/7700 0.00-0327339.8

THE PATENT OFFICE
SN
25 NOV 2003
NEWPORT

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
South Wales
NP10 8QQ

1. Your reference — **for.3148.uk.sb.d**

2. Patent application number *(The Patent Office will fill in this part)* — **0327339.8**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

Fortkey Ltd
Elvingston Science Centre
GLADSMUIR
East Lothian
EH33 1EH

Patents ADP number *(if you know it)* — 8471096001

If the applicant is a corporate body, give the country/state of its incorporation — **UK**

4. Title of the invention — **Inspection Apparatus and Method**

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Kennedys Patent Agency Limited
Floor 5, Queens House
29 St Vincent Place
Glasgow
G1 2DT

Patents ADP number *(if you know it)* — **08058240002**

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
c) any named applicant is a corporate body.
See note (d))

Yes

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	17
Claim *(s)*	
Abstract	
Drawing *(s)*	3 +3 SD

10. If you are also filing any of the following, state how many against each item.

Priority documents	
Translations of priority documents	
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature Kennedys — **KENNEDYS**

Date **24 November 2003**

12. Name and daytime telephone number of person to contact in the United Kingdom — **Simon Black** — **Tel: 0141 226 6826**

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 08459 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

f) For details of the fee and ways to pay please contact the Patent Office.

Inspection Apparatus and Method

The present invention relates to the inspection of objects including vehicles and in particular to the provision of accurate visual information from the underside of a vehicle or other object.

Visual under vehicle inspection is of vital importance in the security sector where it is required to determine the presence of foreign objects on the underside of vehicles. Several systems currently exist which provide the means to perform such inspections.

The simplest of these systems involves the use of a mirror placed on the end of a rod. In this case, the vehicle must be stationary as the inspector runs the mirror along the length of the car performing a manual inspection. Several problems exist with this set-up. Firstly, the vehicle must remain stationary for the duration of the inspection. The length of time taken to process a single vehicle in this way can lead to selected vehicles being inspected, as opposed to all vehicles.

Furthermore, it is difficult to obtain a view of the entire vehicle underside including the central section. Vitally, this could lead to an incomplete inspection and increased security risk.

In order to combat these problems several camera based systems currently exist which either simply display the video live, or capture the vehicle underside onto recordable media for subsequent inspection. One such system involves the digging of a trench into the road. A single camera and mirror system is positioned in the trench, in such a way as to provide a complete view of the vehicle underside as it drives over. The trench is required to allow the camera and mirror system to be far enough away from the underside of the vehicle to capture the entire underside in a single image. This allows a far easier and more reliable inspection than the mirror on the rod. The main problems with this system lie with the requirement for a trench to be excavated in the road surface. This makes it expensive to install, and means that it is fixed to a specific location.

More portable systems exist which utilise multiple cameras built into a housing similar in shape to a speed bump. These have the advantage in that they may be placed anywhere with no restructuring of the road surface required. However, these systems currently display the video footage from the multiple cameras on separate displays, one for each camera. An operator therefore has to study all the video feeds simultaneously as the car drives over the cameras. The task of locating foreign objects using this type of system is made difficult by the fact that the car is passing close to the cameras. This causes the images to change rapidly on each of the

camera displays, making it more likely that any foreign object would be missed by the operator.

It is an object of the present invention to provide a system which provides an image of the entire underside of the vehicle, whilst at the same time being portable and requiring no structural alterations to the road in order to operate.

In accordance with a first aspect of the present invention there is provided an apparatus for inspecting the under side of a vehicle, the apparatus comprising:

a plurality of cameras located at predetermined positions and angles relative to one another, the cameras pointing in the general direction of the area of an object to be inspected; and

image processing means provided with

(i) a first module for calibrating the cameras and for altering the perspective of image frames from said cameras and

(ii) a second module for constructing an accurate mosaic from said altered image frames.

Preferably, the plurality of cameras are arranged in an array. More preferably, the array is a linear array.

In use the apparatus of the present invention may be placed at a predetermined location facing the underside of the object to be inspected, typically a vehicle with the vehicle moving across the position of the stationary apparatus.

Preferably the cameras have overlapping fields of view.

Preferably, the first module is provided with camera positioning means which calculate the predetermined position of each of said cameras as a function of the camera field of view, the angle of the camera to the vertical and the vertical distance between the camera and the position of the vehicle underside or object to be inspected.

Preferably, camera perspective altering means are provided which apply an alteration to the image frame calculated using the angle information from each camera.

Preferably, the images from each of said cameras are altered to the same scale.

More preferably, the camera perspective altering means models a shift in the angle and position of each camera relative to the others and determines an altered view from the camera.

The perspective shift can be used to make images from each camera appear to be taken from an angle normal to the object to be inspected or vehicle underside.

Preferably, the camera calibration means is adapted to correct spherical lens distortion and/or non-equal scaling of pixels and/or the skew of two image axes from the perpendicular.

Preferably, the second module is provided with means for comparing images in sequence which allows the images to be overlapped. More preferably, a Fourier analysis of the images is conducted in order to obtain the translation of x and y pixels relating the images.

In accordance with a second aspect of the present invention there is provided a method of inspecting an area of an object, the method comprising the steps of:

(a) positioning at least one camera, taking n image frames, proximate to the object
(b) acquiring a first frame from the at least one camera
(c) acquiring the next frame from said at least one camera
(d) applying calibration and perspective alterations to said frames
(e) calculating and storing mosaic parameters for said frames
(f) repeat steps c to e n-1 times
(g) mosaicing together the n frames from said at least one camera into a single mosaiced image.

Preferably, the object is the underside of a vehicle.

Preferably, a plurality of cameras is provided, each located at predetermined positions and angles relative to one another, the cameras pointing in the general direction of the object.

Preferably, the predetermined position of each of said cameras is calculated as a function of the camera field of view and/or the angle of the camera to the vertical and/or the vertical distance between the camera and the position of the vehicle underside.

Preferably, images from each of said cameras are altered to the same scale.

Preferably, perspective alteration applies a correction to the image frame calculated using relative position and angle information from each camera.

More preferably, perspective alteration models a shift in the angle and position of each camera relative to the others and determines the view therefrom.

The perspective shift can be used to make images from each camera appear to be taken from an angle normal to the object.

Preferably, calibration of the at least one camera corrects spherical lens distortion and/or non-equal scaling of pixels and/or the skew of two image axes from the perpendicular.

Preferably, mosaicing the images comprises comparing images in sequence, applying fourier analysis to the said images in order to obtain the translation in x and y pixels relating the images.

Preferably, the translation is determined by

(a) Fourier transforming the original images
(b) Computing the magnitude and phase of each of the images
(c) Subtracting the phases of each image
(d) Averaging the magnitudes of the images
(e) Inverse Fourier transforming the result to produce a correlation image.

Preferably the positioning of the at least one camera proximate to the vehicle underside is less than the vehicle's road clearance.

Advantageously, the present invention can produce a still image rather than the video. Therefore, each point on the vehicle underside is seen in context with the rest of the vehicle. Also, any points of interest are easily examinable without recourse to the original video sequence.

In accordance with a third aspect of the present invention there is provided a method of creating a reference map of an object, the method comprising the steps of obtaining a single mosaiced image, selecting an area of the single mosaiced image and recreating or selecting the frame from which said area of the mosaiced image was created.

Preferably, the area of the single mosaiced image is selected graphically by using a cursor on a computer screen.

The present invention will now be described by way of example only with reference to the accompanying drawings of which:

FIGURE 1 is a schematic diagram for the high level processes of this invention;

FIGURE 2 shows the camera layouts for one half of the symmetrical unit in the preferred embodiment;

FIGURE 3 is schematic of the camera pose alteration required to correct for perspective in each of the image frames by;

FIGURE 4 demonstrates the increase in viewable achieved when the camera is angled; and

FIGURE 5 is a flow diagram of the method applied when correcting images for the sensor roll and pitch data concurrently with the camera calibration correction.

A mosaic is a composite image produced by stitching together frames such that similar regions overlap. The output gives a representation of the scene as a whole, rather that a sequential view of parts of that scene, as in the case of a video survey of a scene. In this case, it is required to produce a view of acceptable resolution at all points of the entire underside of a vehicle in a single pass. In this example of the present invention, this is accomplished by using a plurality of cameras arranged in such a way as to achieve full coverage when the distance between the cameras and vehicle is less than the vehicles road clearance.

An example of such a set up using five cameras is provided in figure 2; the width of the system being limited by the wheel base of the vehicle. This diagram shows one half of the symmetric camera setup with the centre camera, angled 0° to the vertical, to the right of the figure.

The notation used in figure 1 is defined as follows:

L_U = Width of unit.

L_c = Maximum expected width of vehicle.

h = Minimum expected height from the camera lenses to the vehicle.

τ = True field of view of camera.

τ' = Assumed field of view of camera, where $\tau' = \tau - \delta\tau$ and $0 < \delta\tau < \tau$.

θ_i = Angles of outer cameras to the vertical, where i=1,2.

L_i = Distances of outer cameras from the central camera, where $L_1 < L_2 < L_u/2$.

In this notation an assumed field of view τ' is used, as opposed to the true field of view τ, the reason for this is twofold. Firstly, it provides a redundancy in the cross-camera overlap regions ensuring the vehicle underside is captured in its entirety. Secondly, in the case of a vehicle that is of maximal width, the use of τ in the positioning calculations will lead to resolution problems at the outer edge of the vehicle. These problems become evident when the necessary image corrections are performed.

Knowing L_c, h, τ', and L_2, then θ_2 may be calculated as

$$\theta_2 = \tan^{-1}\left[\frac{L_c - 2L_2}{2h}\right] - \frac{\tau'}{2}$$

Using this geometry θ_1 cannot be determined analytically. It is therefore calculated as the root of the following equation through use of a root finding technique such as the bisection method

$$\tan\left(\frac{\tau'}{2}+\theta_1\right)+\tan\left(\frac{\tau'}{2}-\theta_1\right)+\left[\tan\left(\frac{\tau'}{2}\right)+\tan\left(\frac{\tau'}{2}-\theta_2\right)-\frac{L_2}{h}\right]=0$$

Following this the distance L_1 is calculated as

$$L_1 = h\left[\tan\left(\frac{\tau'}{2}\right)+\tan\left(\frac{\tau'}{2}-\theta_1\right)\right]$$

The use of these equations ensures the total coverage of the underside of a vehicle whose dimensions are within the given specifications.

In estimating the interframe mosaicing parameters of video sequences there are currently two types of method available. The first uses feature matching within the image to locate objects and then to align the two frames based on the positions of common objects. The second method is frequency based, and uses the properties of the Fourier transform.

Given the volume of data involved (a typical capture rate being 30 frames per second) it is important that a technique which will provide us with a fast data throughput is utilised, whilst also being highly accurate in a multitude of working environments. In order to achieve these goals, the correlation technique based on the frequency content of the images being compared is used. This approach has two main advantages:

1. Firstly, regions that would appear relatively featureless, that is those not containing strong corners, linear features, and such like, still contain a wealth of frequency information representative of the scene. This is extremely important when mosaicing

regions of the seabed for example, as definite features (such as corners or edges) may be sparsely distributed; if indeed they exist at all.

2. Secondly, the fact that this technique is based on the Fourier transform means that it opens itself immediately to fast implementation through highly optimized software and hardware solutions.

Implementation steps in order of their application will now be discussed.

All cameras suffer from various forms of distortion. This distortion arises from certain artefacts inherent to the internal camera geometric and optical characteristics (otherwise known as the intrinsic parameters). These artefacts include spherical lens distortion about the principal point of the system, non-equal scaling of pixels in the x and y-axis, and a skew of the two image axes from the perpendicular. For high accuracy mosaicing the parameters leading to these distortions must be estimated and compensated for. In order to correctly estimate these parameters images taken from multiple viewpoints of a regular grid, or chessboard type pattern are used. The corner positions are located in each image using a corner detection algorithm. The resulting points are then used as input to a camera calibration algorithm well documented in the literature.

The estimated intrinsic parameter matrix A is of the form

$$A = \begin{bmatrix} \alpha & \gamma & u_0 \\ 0 & \beta & v_0 \\ 0 & 0 & 1 \end{bmatrix}.$$

where α and β are the focal lengths in x and y pixels respectively, γ is a factor accounting for skew due to non-rectangular pixels, and (u_0,v_0) is the principle point (that is the perpendicular projection of the camera focal point onto the image plane).

A prerequisite for using the Fourier correlation technique is that consecutive images must match under a strictly linear transformation; translation in x and y, rotation, and scaling. Therefore the assumption is made that the camera is travelling in a direction normal to that in which it is viewing. In the case of producing an image of the underside of a vehicle, this assumption means that the camera is pointing strictly upward at all times. The fact that this may not be the case with the outer cameras leads to the perspective corrected images being used in the processing.

This is accomplished by modelling a shift in the camera pose and determining the normal view from the captured view. In order to accomplish this, the effective focal distance of the camera is required. This value is needed in order to perform for the projective transformation from 3D coordinates into image pixel coordinates, and is gained during the intrinsic camera parameter estimation. Figure 3 shows a diagram of this pose shift.

When correcting for perspective, the new camera position is at the same height as the original viewpoint, not the slant range distance. Thus all of the images from each of the cameras are corrected to the same scale.

For each image comparison of images from the chosen camera, it is assumed that there is no rotation or

zooming differences between the frames. This way only the translation in x and y pixels need be estimated. Having obtained the necessary parameters of the differences in position of the two images, they can be placed in their correct relative positions. The next frame is then analysed in a similar manner and added to the evolving mosaic image. A description of the implementation procedures used in this invention for translation estimation in Fourier space will now be given.

In Fourier space, translation is a phase shift. The differences in the phase to determine the translational shift. Let the two images be described by $f_1(x,y)$ and $f_2(x,y)$ where (x,y) represents a pixel at this position should be utilised. Then for a translation (dx,dy) the two frames are related by

$$f_2(x,y) = f_1(x+dx, y+dy)$$

The Fourier transform magnitudes of these two images are the same since the translation only affects the phases. Let our original images be of size $(cols,rows)$, then each of these axes represents a range of 2π radians. So a shift of dx pixels corresponds to $2\pi.dx/cols$ shift in phase for the column axis. Similarly, a shift of dy pixels corresponds to $2\pi.dy/rows$ shift in phase for the row axis.

To determine a translation, a Fourier transform of the original images, compute the magnitude (M) and phases (ϕ) of each of the pixels and subtract the phases of each pixel to get $d\phi$. The average of the magnitudes (they

should be the same) and the phase differences are taken and a new set of real ($\Re$) and imaginary ($\Im$) values as $\Re = M\cos(d\phi)$ and $\Im = M\sin(d\phi)$ is computed. These $(\Re,\Im)$ values are then inverse Fourier transformed to produce an image. Ideally, this image will have a single bright pixel at a position (x,y), which represents the translation between the original two images, whereupon a subpixel translation estimation may be made.

An important point to consider is which camera to use in calculating the mosaicing parameters. When asking this question the primary consideration is that of overlap, and how to get the maximum effective overlap between frames. It is here that an added benefit is found to having the outer cameras angled. If the centre camera is used then the distance subtended by the view of a single frame along the central axis of that frame is

$$d_c = 2h\tan(\tau'/2)$$

When the camera is rolled to an angle of θ_1 degrees to the vertical as shown in figure 2, then the distance subtended by the view of a single frame along the central axis is

$$d_1 = 2h\tan(\tau'/2)/\cos(\theta_1)$$

which is greater than d_c for all $\theta_1 \neq 0$. This property is illustrated in figure 4.

Care must be exercised here however as according to this argument one of the cameras at the greatest angle θ_2 should be used. Two reasons count against this choice.

Firstly, the pixel resolution at the outer limits of the corrected image is the poorest of all the imaged areas. Secondly, and most importantly, due to the enforced redundancy in the coverage, and that most vehicles will fall short of the maximum width limits, the outer region of this image (that which should correspond to the maximum overlap) does not view the underside of the vehicle at all. In this case most of the image will contain stationary information. For these reasons it is recommended that one of the cameras angled at θ_1 degrees should be used.

Given the mosaicing parameters, the final stage of the process is to stitch the corrected images into a single view of the underside of the vehicle. The first point to stress here is that mosaicing parameters are only calculated along the length of the vehicle, not between each of the cameras. The reason for this is that there will be minimal, as well as variable, overlap between camera views. These problems mean that any mosaicing attempted between the cameras will be unreliable at best. For this reason each of the camera images at a given instant in time are cropped to an equal number of rows, and subsequently placed together in a manner which assumes no overlap.

These image strips are then stitched together along the length of the car using the calculated mosaicing parameters, providing a complete view of the underside of the vehicle in a single image. This stitching is performed in such a way that the edges between strips are blended together. In this blending the higher resolution central portions of each frame are given a greater weighting.

A final point to note here is that when the final stitched result is calculated, each of the pixel values is interpolated directly from the captured images. This is achieved through use of pixel maps relating the pixel positions in the corrected image strips directly to the corresponding sub-pixel positions in the captured images. The advantage of adopting this approach is that only a single interpolation stage is used. This has the effect of not only reducing memory requirements and saving greatly on processing time, but also the resultant image is of a higher quality than if multiple interpolation stages had been used; a schematic for this process is provided in figure 5. The process of generating the pixel maps correcting for camera calibration and perspective correction are combined mathematically in the following way.

If $\underline{u}$ is the corrected pixel position, the corresponding position in the reference frame of the camera, normalised according the camera focal length in y pixels (β) and centred on the principle point (u_0, v_0), is $\underline{c}'=[(c_1'',c_2'',c_3'')/c_4''-(u_0,v_0)]/\beta$ where $\underline{c}''=PR_yR_xP^{-1}\underline{u}$. The pitch and roll are represented by the rotation matrices R_x and R_y respectively, with P being the perspective projection matrix which maps real world coordinates onto image coordinates. Following this the pixel position in the captured image is calculated as $\underline{c}=A\tau_{c'}\underline{c}'$. The scalar $\tau_{c'}$ represents the radial distortion applied at the camera reference frame coordinate $\underline{c}'$. The matrix A is as defined previously.

The apparatus and method of the present invention may also be used to re-create each of the images from which the mosaiced image was created.

Once the mosaiced image has been created, it can be displayed on a computer screen. If an area of the image is selected on the computer screen using the computer cursor, the method and apparatus of the present invention can determine the image from which this part of the mosaic was created and can select this image frame for display on the screen. This can be achieved by identifying and selecting the correct image for display or by reversing the mosaicing process to return to the original image.

In practice, this feature may be used where a particular part of an object is of interest. If for example, the viewer wishes to inspect a part of the exhaust on the underside of a vehicle then the image containing this part of the exhaust can be recreated.

Improvements and modifications may be incorporated herein without deviating from the scope of the invention.

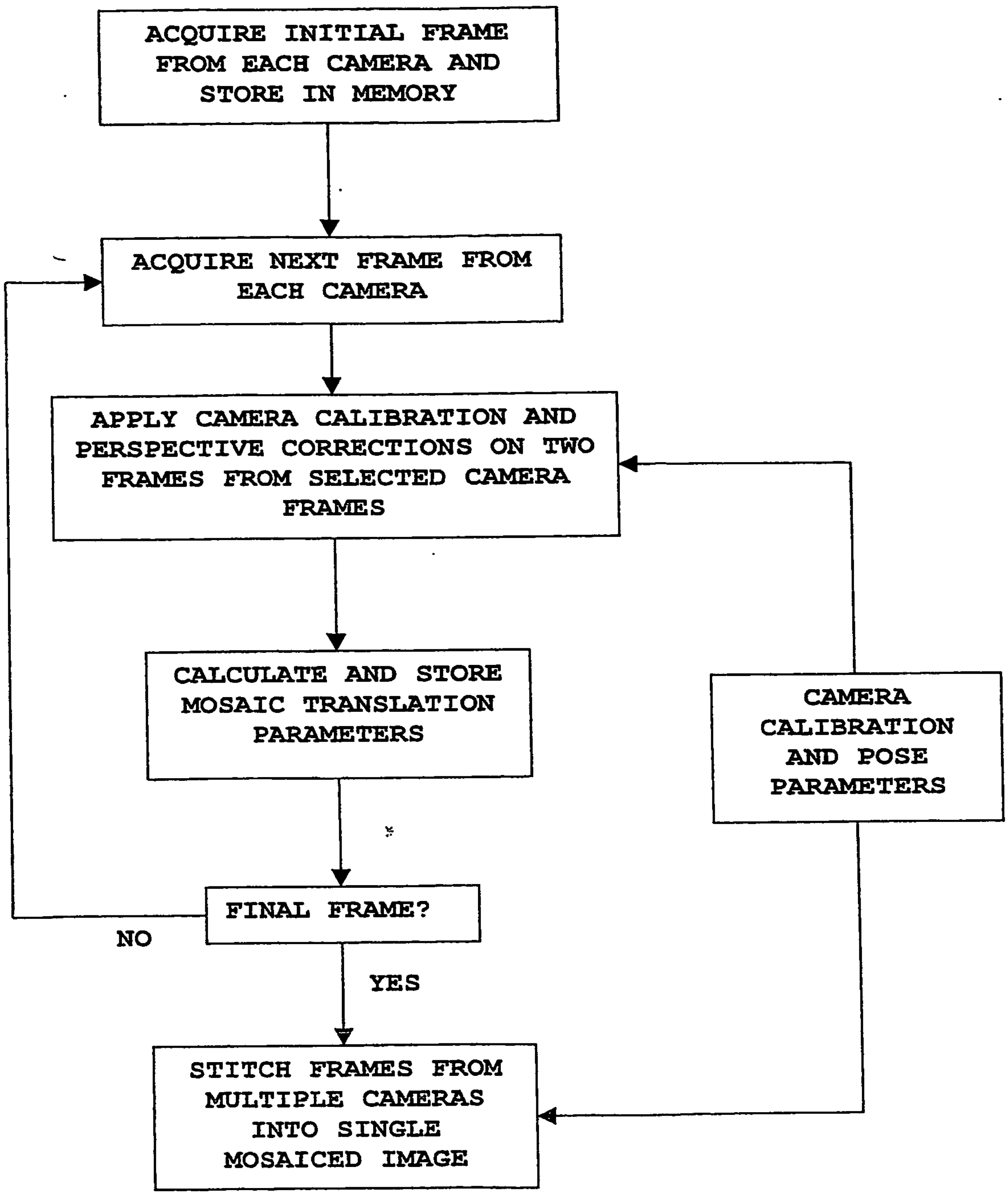
ACQUIRE INITIAL FRAME FROM EACH CAMERA AND STORE IN MEMORY
ACQUIRE NEXT FRAME FROM EACH CAMERA
APPLY CAMERA CALIBRATION AND PERSPECTIVE CORRECTIONS ON TWO FRAMES FROM SELECTED CAMERA FRAMES
CALCULATE AND STORE MOSAIC TRANSLATION PARAMETERS
CAMERA CALIBRATION AND POSE PARAMETERS
FINAL FRAME?
NO
YES
STITCH FRAMES FROM MULTIPLE CAMERAS INTO SINGLE MOSAICED IMAGE

FIGURE 1

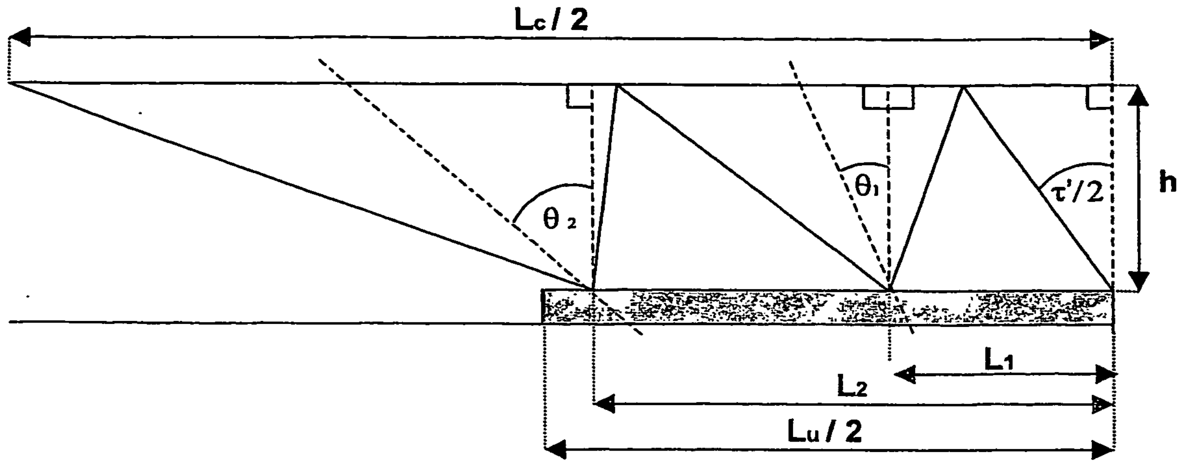

FIGURE 2

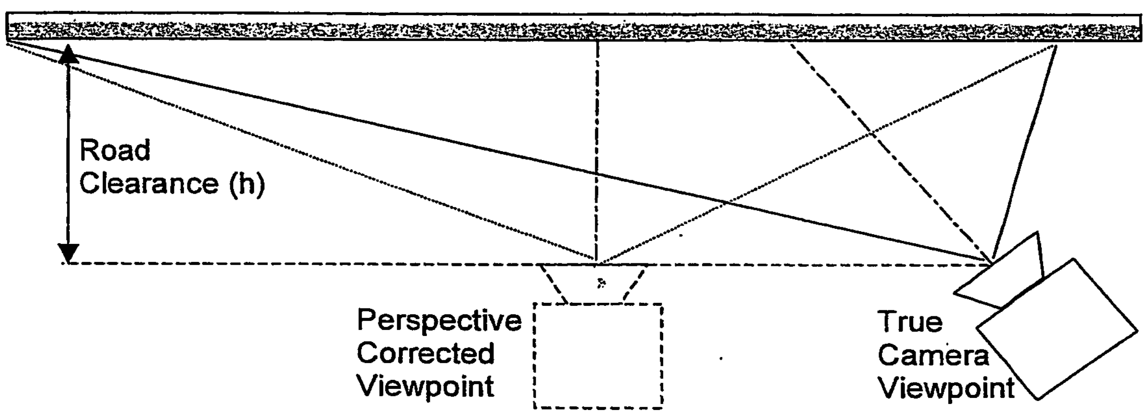

FIGURE 3

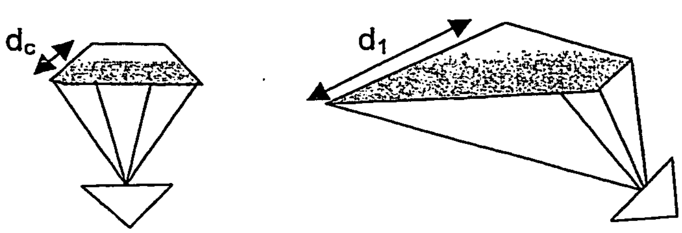

FIGURE 4

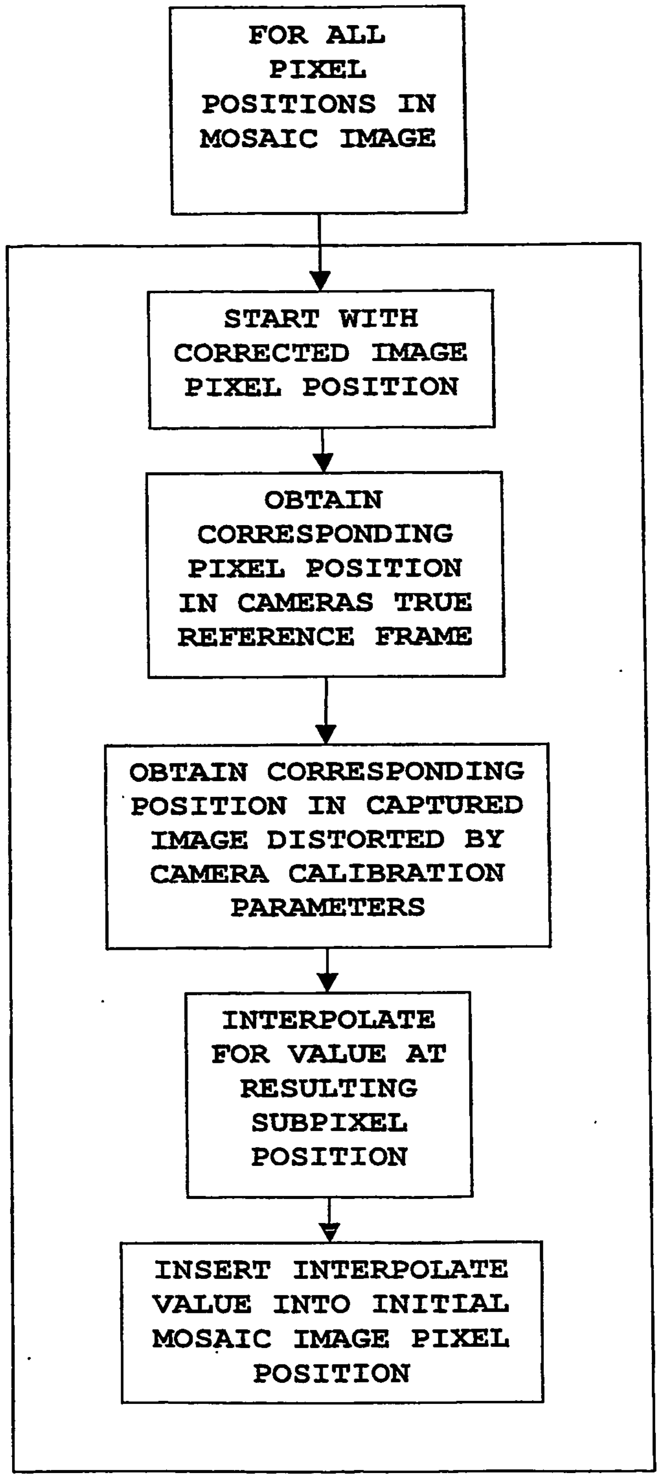
FOR ALL PIXEL POSITIONS IN MOSAIC IMAGE
START WITH CORRECTED IMAGE PIXEL POSITION
OBTAIN CORRESPONDING PIXEL POSITION IN CAMERAS TRUE REFERENCE FRAME
OBTAIN CORRESPONDING POSITION IN CAPTURED IMAGE DISTORTED BY CAMERA CALIBRATION PARAMETERS
INTERPOLATE FOR VALUE AT RESULTING SUBPIXEL POSITION
INSERT INTERPOLATE VALUE INTO INITIAL MOSAIC IMAGE PIXEL POSITION

FIGURE 5

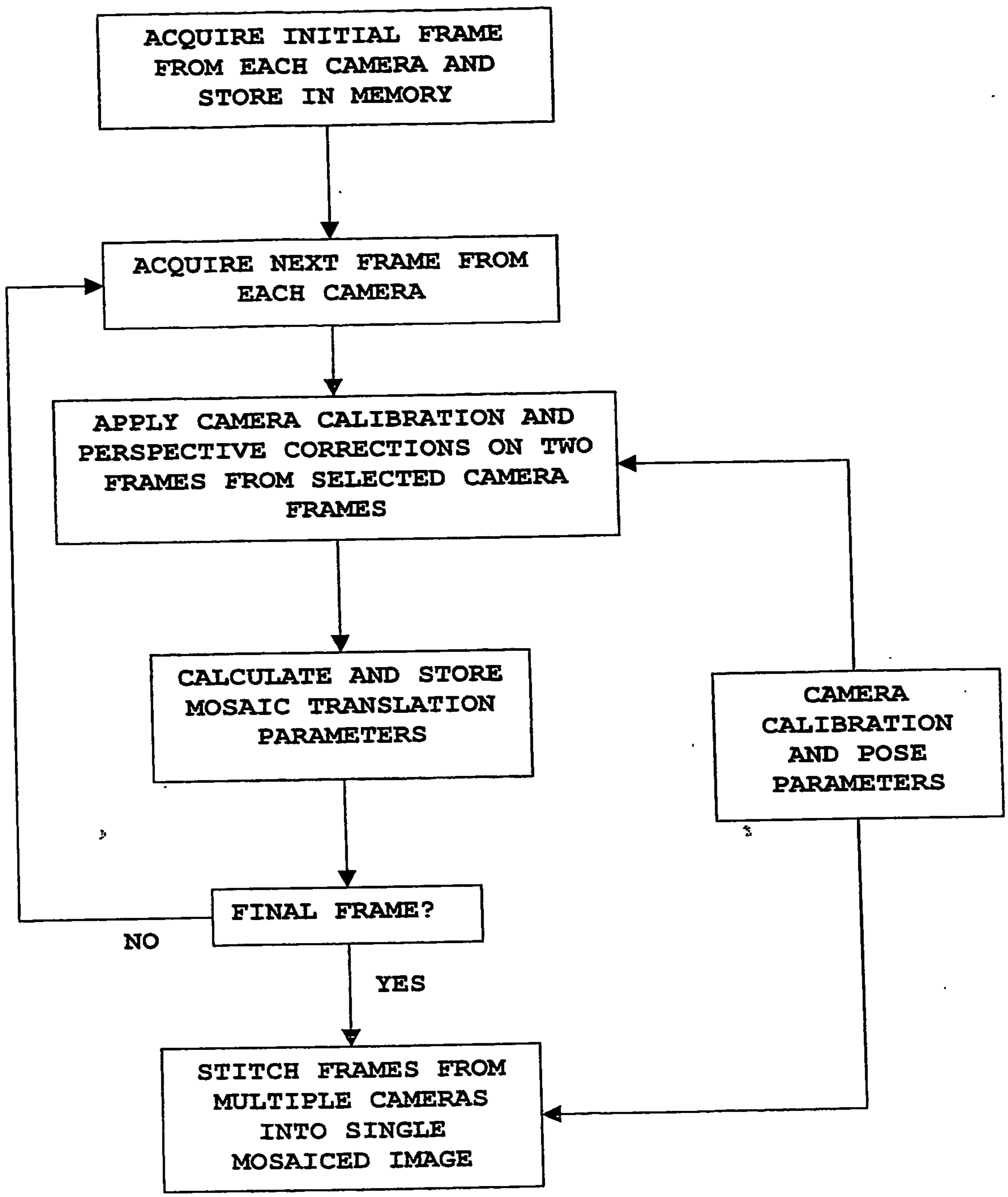
ACQUIRE INITIAL FRAME FROM EACH CAMERA AND STORE IN MEMORY
ACQUIRE NEXT FRAME FROM EACH CAMERA
APPLY CAMERA CALIBRATION AND PERSPECTIVE CORRECTIONS ON TWO FRAMES FROM SELECTED CAMERA FRAMES
CALCULATE AND STORE MOSAIC TRANSLATION PARAMETERS
CAMERA CALIBRATION AND POSE PARAMETERS
FINAL FRAME?
NO
YES
STITCH FRAMES FROM MULTIPLE CAMERAS INTO SINGLE MOSAICED IMAGE

FIGURE 1

2/3

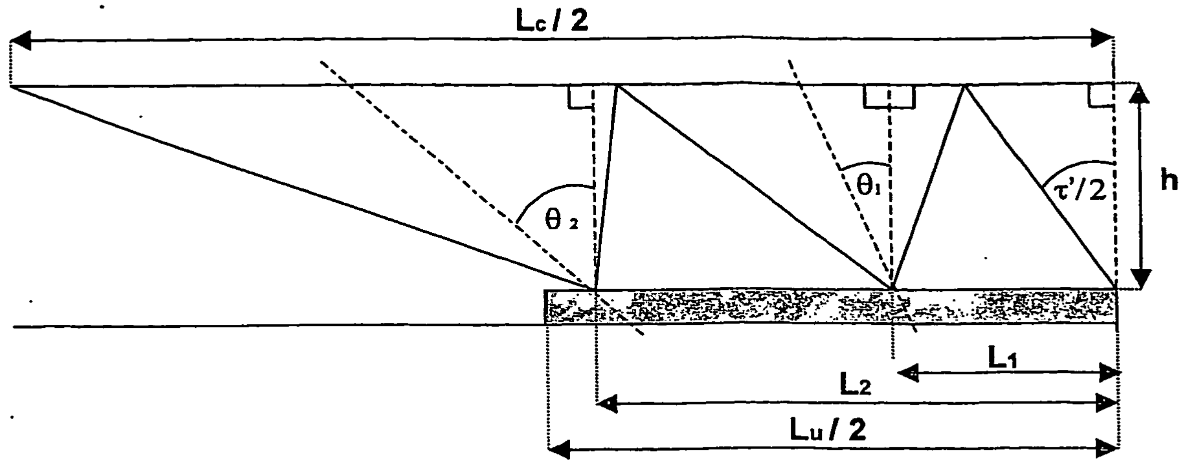

FIGURE 2

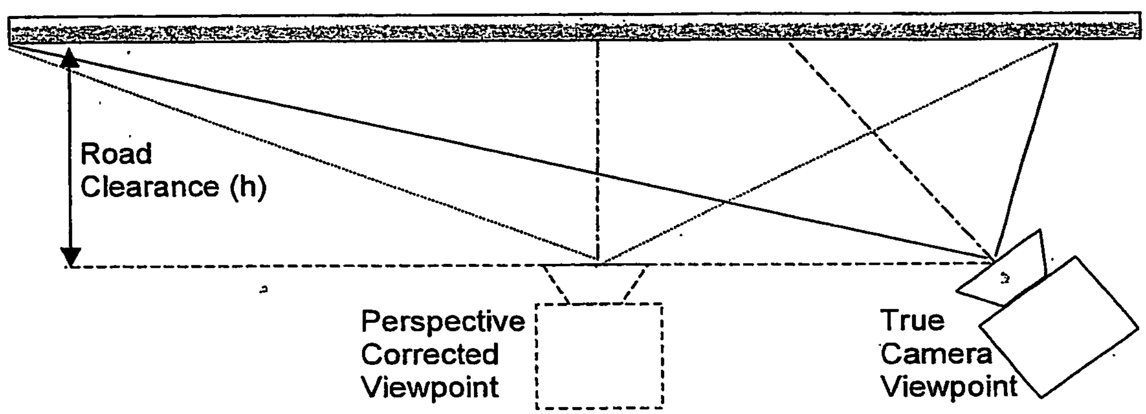

FIGURE 3

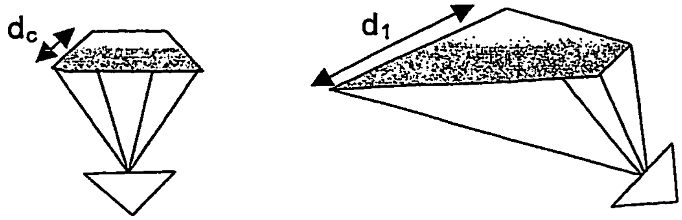

FIGURE 4

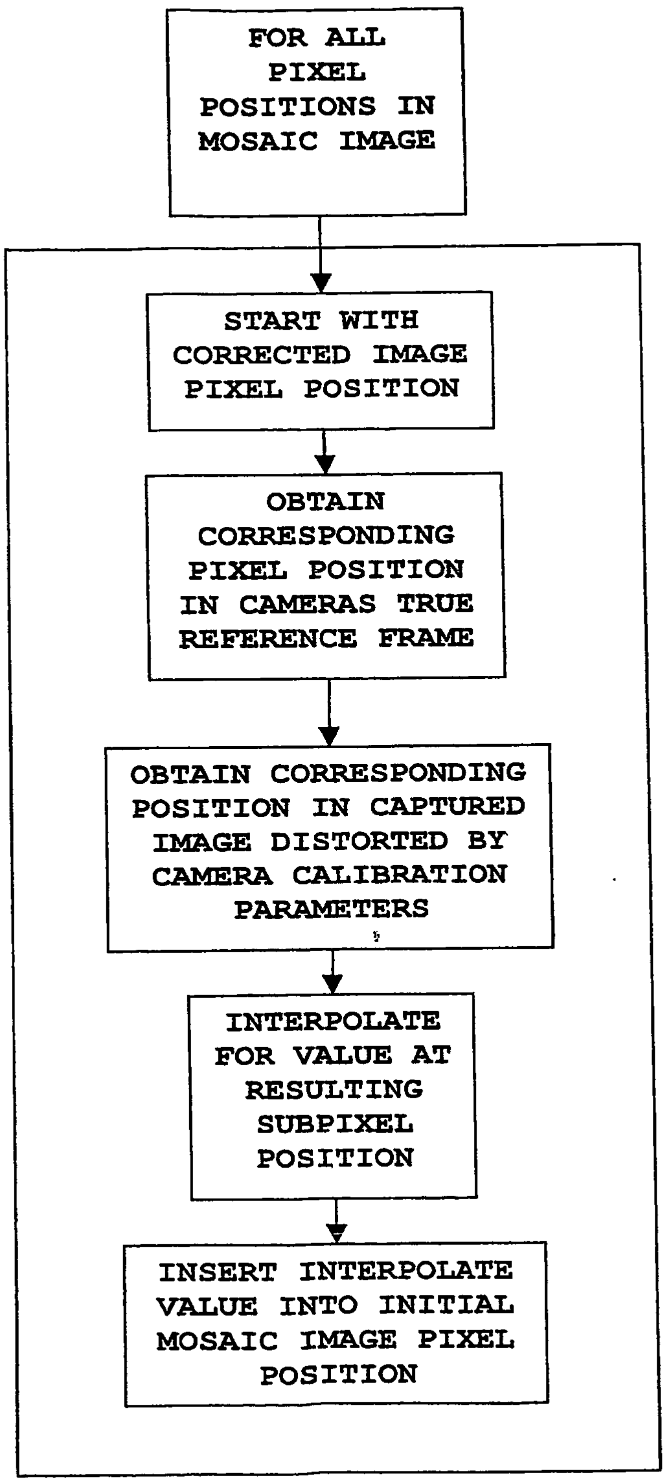
FOR ALL PIXEL POSITIONS IN MOSAIC IMAGE
START WITH CORRECTED IMAGE PIXEL POSITION
OBTAIN CORRESPONDING PIXEL POSITION IN CAMERAS TRUE REFERENCE FRAME
OBTAIN CORRESPONDING POSITION IN CAPTURED IMAGE DISTORTED BY CAMERA CALIBRATION PARAMETERS
INTERPOLATE FOR VALUE AT RESULTING SUBPIXEL POSITION
INSERT INTERPOLATE VALUE INTO INITIAL MOSAIC IMAGE PIXEL POSITION

FIGURE 5

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/GB04/004981

International filing date: 25 November 2004 (25.11.2004)

Document type: Certified copy of priority document

Document details: Country/Office: GB
Number: 0327339.8
Filing date: 25 November 2003 (25.11.2003)

Date of receipt at the International Bureau: 24 January 2005 (24.01.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record.

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- [x] BLACK BORDERS
- [ ] IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- [ ] FADED TEXT OR DRAWING
- [ ] BLURRED OR ILLEGIBLE TEXT OR DRAWING
- [ ] SKEWED/SLANTED IMAGES
- [x] COLOR OR BLACK AND WHITE PHOTOGRAPHS
- [ ] GRAY SCALE DOCUMENTS
- [x] LINES OR MARKS ON ORIGINAL DOCUMENT
- [x] REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- [x] OTHER: ______________________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.